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ABSTRACT

In 1994, the Student Assessment was administered to approximately 12,000 students at 197 new High Schools that Work (HSTW) sites in 13 states; student scores from the mathematics portion of the assessment were analyzed. Vocational completers had an average mathematics score of 282.0, which was 13 points below the HSTW mathematics goal, while the average mathematics score for academic students nationwide in 1990 was 316.8. White vocational completers scored significantly higher than African American vocational completers, who scored significantly higher than African Americans in the national sample. Student achievement reflected teachers' beliefs and expectations. Mathematics achievement improved when career-bound students took higher-level mathematics courses taught to high standards, when students had opportunities to use and discuss mathematics as it related to real circumstances, when families supported their children with studies, and when a guidance system reinforced the importance of mathematics. Schools faced six challenges in raising the mathematics achievement of career-bound students: raising expectations for mathematics learning, getting students to see the need for mathematics outside of class and school, helping mathematics teachers use a variety of teaching strategies, developing a guidance system that involves parents, holding students to higher standards and providing extra help, and supporting mathematics and vocational teachers with staff development and resource materials. (YLB)

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Mathematics: A Report on Improving Career-Bound Students' Learning

High Schools That Work

Gene Bottoms
Alice Presson

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HIGH SCHOOLS THAT WORK

A report on improving career-bound students' learning

mathematics

High-Level Mathematics Knowledge and Skills Are Essential for Success in Work and Education

by Gene Bottoms and Alice Presson

"Employers need men and women with the ability to read with understanding, the ability to communicate clearly both by the written and spoken word, the ability to think through a problem or situation; the ability to calculate with at least a rudimentary understanding of algebra, geometry, and elementary statistics; and the ability to analyze." [1]

John L. Clendenin, Chairman of the Board, BellSouth Corporation

The job requirements described by John Clendenin are not unreasonable. Yet many American high school graduates are poorly prepared to join the nation's workforce or to continue their education.

Fewer than one-fourth (23 percent) of public high school graduates in 1992 completed the college preparatory curriculum recommended by the National Commission on Excellence in Education.[2] The percent of students completing a vocational major declined between 1982 and 1992, and the percent completing neither a college preparatory program nor a vocational program rose to 55 percent in the same 10-year period.

Having fewer students enrolled in vocational studies did not result in higher standards or more rigorous course-taking patterns. Career-bound students[3] who graduated from high school in 1992 averaged less than one Carnegie Unit in algebra or higher mathematics, fewer than four units in English, only three-fourths of a unit in biology, and no units in chemistry. No wonder so many of these students have trouble finding a good job.

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1 John L. Clendenin, "Education Is Business' Bottom Line," *Georgia Trend*, 1994.

2 The National Commission on Excellence in Education recommends a college preparatory curriculum consisting of four Carnegie Units in English, three in social studies, three in science, three in mathematics, two in a foreign language, and one-half in computer science. (Source: U.S. Department of Education, National Center for Education Statistics, *National Education Longitudinal Study of 1989, Second Followup Survey, 1994.*)

3 The *High Schools That Work* program defines career-bound students as high school students who plan to work, attend a two-year community college or vocational-technical school, participate in an apprenticeship program, or enter the military after high school graduation. Career-bound students are not planning to enter a four-year college or university but may make that decision at some future time.

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The Southern Regional Education Board's Plan for Preparing Career-Bound Students

The Southern Regional Education Board (SREB)-State Vocational Education Consortium contends that the way to raise career-bound students' academic and vocational achievement is for school board members, school administrators, teachers, and parents to:

- Motivate students to take more demanding courses and to work hard in them;
- Prompt teachers to use instructional approaches that help students see connections between school studies and the workplace.

Through its *High Schools That Work* program involving over 400 high schools in 19 states, SREB is working to improve the achievement of career-bound students in reading, mathematics, science, and technical studies. The program's goals and key practices (see page 34) serve as a framework for schools as they change what and how they teach and what they expect of career-bound students.

SREB's goal is to close by at least one-third the achievement gap between vocational completers[4] at *HSTW* sites and academic students[5] nationwide. Progress is measured by the *High Schools That Work* Student Assessment, a series of tests taken by vocational completers in their senior year at participating schools. The tests (in reading, mathematics, and science) draw questions from a pool of items in the 1990 National Assessment of Educational Progress (NAEP). The Educational Testing Service prepared the *HSTW* Student Assessment for SREB.

In 1994, SREB administered the Student Assessment to approximately 12,000 students at 197 new *HSTW* sites[6] in 13 states. This report focuses on student scores from the mathematics portion of the assessment. It describes achievement, course-taking patterns, and student and teacher perspectives at a group of schools untouched by the *HSTW* program. The report addresses six challenges new *HSTW* sites face in raising mathematics achievement and recommends ways to improve mathematics instruction.

The 1994 *HSTW* Student Assessment established baseline data for schools that joined the program between April 1993 and March 1994. It began the second cycle of the *HSTW* assessment effort. In the first cycle, *HSTW* sites participated in testing in 1988, 1990, and 1993.

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4 The *High Schools That Work* program defines a vocational completer as a student who completes at least four credits in an approved vocational area and takes three mathematics and three science courses. At least two of the courses in each category should be equal to the college preparatory level.

5 The term "academic students" used in this report refers to students who complete a college preparatory high school curriculum.

6 New *High Schools That Work* sites are defined as schools that joined the program in 1993 and administered the *HSTW* Student Assessment for the first time in 1994. New sites did not begin implementing the *HSTW* key practices until 1993.

The average mathematics score of vocational completers at new *HSTW* sites in 1994 was 282.0, while the average mathematics score for academic students nationwide in 1990 was 316.8. The SREB mathematics goal is 295.0. New *HSTW* sites are committed to meeting this goal by changing school and classroom practices. SREB has prepared this report as a resource document to help them do so.

Assessing the Mathematics Knowledge and Skills of Career-Bound High School Students

The *HSTW* Student Assessment mathematics examination represents what students need to know and be able to do in mathematics. It assesses students' level of understanding and use of mathematical concepts, their capacity to select and apply appropriate mathematics procedures, and their ability to solve problems. It also assesses students' knowledge in content areas.

Some items on the examination require students to solve real-life mathematics problems, while others ask students to select from multiple-choice options. The examination often asks students to explain their responses.

The content areas covered in the mathematics examination include the following concepts and skills:

- **Numbers and Basic Mathematics Operations**
  - Interpret and perform operations with fractions and decimal numbers and convert from one to the other.
  - Understand percents less and greater than 100.
  - Understand some properties of exponents and use mathematical notation to interpret expressions, including ones that use exponents and negative integers.
  - Recognize scientific notation on a calculator and make conversions between scientific notation and decimal notation.
- **Measurement and Geometry**
  - Apply knowledge of the area and perimeter of rectangles and triangles to solve problems and find the circumference of circles and the surface area of solid figures.
  - Apply the Pythagorean theorem to solve problems in indirect measurement.
  - Apply knowledge of the properties of geometric figures to solve problems such as determining the slope of a line.
- **Data Analysis**
  - Calculate averages and interpret data from tables, pictographs, and graphs.
  - Compute relative frequency and distributions from tables.
  - Determine the probability of a simple event.

- **Algebra**
  - Demonstrate knowledge of algebra by graphing points in the Cartesian plane and perform several algebraic operations.
  - Solve two- and three-step linear equations and solve inequalities by substitution.
  - Apply a rule for simple functional relations, determine the *nth* term of a sequence, and disprove an algebraic generalization.

The practical aspects of the mathematics examination reflect SREB's efforts to prompt teachers of career-bound students to use real-life problems in teaching mathematics and to emphasize its applications. Leading mathematics educators say that career-bound students increasingly need to learn to use sophisticated mathematics processes to solve problems from everyday life and work.

Mathematics specialists Susan L. Forman and Lynn Arthur Steen[7] remind educators that mathematics has become the language of the technical workforce. "The same powerful ideas that have made mathematics the language of science have also made it the chief tool of manufacturing, quality control, planning, marketing, and other necessities of modern business," they said.

"Demands of quality control reinforce the importance of probability and statistics; the ubiquitous role of robotics, computer graphics, and virtual reality simulations provide increased demand for three-dimensional geometry; and the insatiable demand for dealing with data in industries ranging from banking to sports reinforces the importance of algorithms, data analysis, and related mathematics," Forman and Steen said.

Mathematics Achievement of Career-Bound Students at New *High Schools That Work* Sites and Nationwide

Vocational completers at SREB's 197 new sites in 1994 had an average mathematics score of 282.0, which is 13 points below the *HSTW* mathematics goal of 295.0. However, they performed significantly better (by 5.3 points) than vocational students in the national sample, a random group of students nationwide who took the NAEP mathematics test (see Table 1). Twenty-two (11 percent) of the 197 new *HSTW* sites taking part in the assessment met the SREB mathematics goal.

Vocational completers at SREB's new *HSTW* sites correctly answered fewer than half of the items in the mathematics content areas of measurement, data analysis, and algebra (see Table 2). They correctly answered only a slightly larger percent of questions requiring them to demonstrate an understanding of geometry, mathematical procedures, and use of mathematical concepts in solving problems. Students at these schools had the highest

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7 Forman, Susan L. and Steen, Lynn Arthur. (April 1995). "Mathematics for Work and Life" in *75 Years of Progress: Prospects for School Mathematics.* National Council of Teachers of Mathematics. Reston, VA.

Table 1

Comparison of Mathematics Scores of Vocational Completers at New *HSTW* Sites with Scores of Academic and Vocational Students Nationwide and with the National Average of All Students

SREB Mathematics Goal	Vocational Completers at New *HSTW* Sites	National Sample of Vocational Completers	National Sample of Academic Students	National Average of All Students
295.0	282.0 (0.4)	276.7 (1.6)	316.8 (0.4)	298.9 (0.4)

Note: Scores for students in the national samples are based on the 1990 National Assessment of Educational Progress (NAEP). The difference between the average score of vocational completers at new *HSTW* sites and the average scores of students in the national samples is statistically significant at the .01 level. Standard errors are indicated in parentheses.

Table 2

Comparison of Percent of Correct Responses in Areas of Mathematics Content and Procedures by Vocational Completers at New *HSTW* Sites, in the National Sample, and at High-Scoring New *HSTW* Sites

Mathematics Area	Percent Correct		
	New *HSTW* Sites	National Sample of Vocational Students	High-Scoring New *HSTW* Sites
Numbers and Operations	65	50	69
Measurement	49	39	52
Geometry	54	38	59
Data Analysis, Statistics, and Probability	49	43	53
Algebra and Functions	47	33	53
Conceptual Understanding	68	37	73
Procedural Knowledge	53	37	58
Problem Solving	53	39	57

Note: Percentages are rounded to the nearest whole number.

proportion of correct responses on items dealing with conceptual understanding. They needed the most help in understanding and using mathematical concepts related to:

- Measurement;
- Data analysis, statistics, and probability;
- Algebra and functions;
- Problem solving and procedural knowledge.

SREB's vocational completers had a larger percent of correct responses in all mathematics areas when compared to the national sample of vocational students. Yet, these students are capable of achieving at an even higher level, as witnessed by the mathematics test performance of students at high-scoring[8] new *HSTW* sites. Despite this achievement, the small percentage of correct answers in all topics at all schools is well below the level considered satisfactory by industry and postsecondary institutions.

The scores revealed no statistical difference in mathematics achievement by males and females at new *HSTW* sites, including high-scoring new sites. Female students at the new sites performed significantly higher than females in the national sample (see Table 3).

The Impact of School and Classroom Practices on Mathematics Achievement

SREB data continue to show that career-bound students' mathematics achievement is higher when:

- Students work in mathematics classes, rather than watch their teachers work;
- The emphasis is on enrolling students in mathematics courses containing content from Algebra I, geometry, Algebra II, trigonometry, and elementary statistics, taught to high standards, rather than sorting students into low-level courses with lower standards;
- Teachers require students to use mathematics in other academic courses, in vocational courses, and in solving career-related problems, rather than teaching mathematics for its own sake;
- The school board, the school, and students' families collaborate in motivating students to complete a challenging mathematics curriculum and in providing the extra help and time they need, rather than pressuring teachers to give a passing grade to students who do not earn it;
- Students work several hours a week outside of class (by themselves and with other students) on challenging mathematics assignments;
- The school provides a guidance system in which teachers, counselors, and parents help students see the relationship between a challenging mathematics curriculum and future educational and career goals.

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[8] High-scoring new *High Schools That Work* sites are new sites that had scores in two of three areas (reading, mathematics, and science) that ranked in the top one-third of the 197 sites participating in the 1994 *High Schools That Work* Student Assessment.

Table 3

Comparison of Average Mathematics Scores of Vocational Completers by Gender at New *HSTW* Sites, at High-Scoring New *HSTW* Sites, and in the National Sample

	New *HSTW* Sites	High-Scoring New *HSTW* Sites	National Sample of Vocational Students
Female	281.2 (0.5)	292.6 (0.8)	273.0 (2.5)
Male	282.8 (0.5)	292.0 (0.9)	279.6 (2.1)
SREB Mathematics Goal	**295.0**		

Note: Standard errors are indicated in parentheses.

White vocational completers scored significantly higher than African American vocational completers at new *HSTW* sites, and African Americans at those sites scored significantly higher than African Americans in the national sample (see Table 4). However, white students' scores at new *HSTW* sites were not significantly higher than those of white students nationally. All groups of students scored significantly higher at the high-scoring new sites than in the national sample (see Tables 3-4).

Table 4

Comparison of Average Mathematics Scores of Vocational Completers by Race/Ethnicity at New *HSTW* Sites, at High-Scoring New *HSTW* Sites, and in the National Sample of Vocational Students

Race/ Ethnicity	All New *HSTW* Sites	Percent at All New *HSTW* Sites	High-Scoring New *HSTW* Sites	Percent at High-Scoring New *HSTW* Sites	National Sample of Vocational Students	Percent in National Sample of Vocational Students
African American	269.8 (0.7)	26	279.5 (1.3)	19	259.5 (3.4)	22
Latino/Hispanic	276.5 (1.8)	4	285.3 (4.6)	2	266.3 (5.0)	10
White	286.8 (0.4)	69	295.5 (0.7)	78	284.1 (1.8)	64
SREB Mathematics Goal	**295.0**					

Note: School leaders at participating *HSTW* sites selected students who had completed four Carnegie Units in a vocational concentration. The national sample of vocational students consists of students who identified themselves as vocational students. Standard errors are indicated in parentheses.

Percentages are rounded to the nearest whole number. They do not total 100 because an "other" category is not shown here.

Mathematics Achievement of Career-Bound Students at New *High Schools That Work* Sites by Vocational Areas

Students in business/office and technical programs at new *HSTW* sites had the highest average mathematics scores, while students in home economics programs had the lowest (see Table 5). Among the new *HSTW* sites, no vocational programs had students whose average scores met SREB's mathematics goal. However, students enrolled in business/office and technical programs at high-scoring new *HSTW* sites had average mathematics scores that exceeded the SREB mathematics goal.

No significant difference exists between the mathematics achievement of students earning four Carnegie units in vocational courses and those earning five or more units. Seventy-five percent of vocational completers from new *HSTW* sites received five or more vocational credits in 1994.

Students Do What Teachers Expect Them to Do

Career-bound students who reported that they studied outside of class up to one hour per day scored significantly higher in mathematics than students who reported doing no homework (see Table 6). Thirty-six percent of students participating in the 1994 *HSTW* Student Assessment in mathematics reported that they did not have or did not do homework. Sixty-six percent reported that their vocational teachers did not assign homework. This evidence of low standards and expectations for career-bound students is consistent

Table 5

Comparison of Students' Average Mathematics Scores by Vocational Program at All New *HSTW* Sites and at High-Scoring New *HSTW* Sites

Vocational Program	All New *HSTW* Sites	Percent of Assessed Students Enrolled in Program	High-Scoring New *HSTW* Sites	Percent of Assessed Students Enrolled in Program
Agriculture	278.0 (1.2)	9	284.1 (1.9)	9
Business/Office	287.8 (0.6)	29	297.7 (1.0)	35
Health	277.9 (1.2)	9	291.1 (1.9)	9
Home Economics	270.3 (1.1)	10	281.6 (2.4)	7
Marketing	281.1 (1.3)	7	289.5 (2.0)	8
Technical	286.7 (0.9)	17	297.8 (1.7)	14
Trade/Industrial	279.4 (0.8)	16	288.5 (1.4)	14
SREB Mathematics Goal	**295.0**			

Note: Standard errors are indicated in parentheses. Percentages are rounded to the nearest whole number.

with findings from the 1994 *HSTW* Teacher Survey.[9] Forty-eight percent of surveyed teachers said they assigned one hour or less of homework per week to career-bound students. Vocational teachers require even less effort from their students. For example, 77 percent of vocational teachers reported that they assigned only one hour or less of homework per week.

Assigning more mathematics homework is not enough to improve mathematics achievement. Students need assignments that require them to apply abstract concepts and procedures to real-world problems. Homework should stretch students beyond their current understanding of mathematics.

In many high schools, career-bound students have created a norm of acceptable behavior: It is okay for them to be intelligent, but it is not okay for them to study hard. Instead, most career-bound students spend their free time working to earn money. The 52 percent of employed students at new *HSTW* sites who worked 21 or more hours per week had lower average mathematics scores than students who worked less.

School board members, school administrators, teachers, parents, and community leaders need to send the message that mathematics achievement is important for career-bound students as they enter and advance in a career pathway, find and keep a job, and engage in further study. Schools need to emphasize that mathematics learning is a priority.

Table 6

Comparison of Students' Average Mathematics Scores with the Amount of Homework Students Completed at All New *HSTW* Sites and at High-Scoring New *HSTW* Sites

	All New *HSTW* Sites		High-Scoring New *HSTW* Sites	
Amount of Homework	Average Mathematics Scores	Percent of Students	Average Mathematics Scores	Percent of Students
Did not have or did not do homework	280.4 (1.5)	36	288.2 (2.6)	32
Completed up to one hour of homework per day	284.2 (0.8)	48	294.8 (1.2)	54
SREB Mathematics Goal	**295.0**			

Note: Standard errors are indicated in parentheses. Differences in scores are statistically significant at the .05 level. Percentages are rounded to the nearest whole number.

[9] SREB administered the 1994 *High Schools That Work* Teacher Survey to 6,334 academic and vocational teachers at *HSTW* sites.

HSTW sites are demonstrating that career-bound students who work hard in mathematics also achieve at a higher level. Yet, the *HSTW* teacher survey at new *HSTW* sites revealed that many schools fail to place a high priority on career-bound students' academic performance. Forty-seven percent of surveyed teachers admitted that their schools expect too little of career-bound students. Sixty-two percent of all teachers, and 65 percent of vocational teachers, said career-bound students' mathematics skills need improvement. Thirty-three percent of all teachers said their schools expect career-bound students to enroll in lower-level courses.

Completing Algebra II at new *HSTW* sites is associated with meeting the SREB mathematics goal of 295. Only 39 percent of students who took the *HSTW* Student Assessment in mathematics in 1994 completed Algebra II, but they scored an average of 297.4, which is two points higher than the SREB mathematics goal (see Table 7). Over half of the students (51 percent) said their teachers did not encourage them to take more mathematics courses. These students had an average mathematics score that was significantly lower than that of students who said their teachers encouraged them to take more mathematics courses (277.7 compared to 286.2).

Table 7

Comparison of Average Mathematics Scores by Mathematics Courses Taken at All New *HSTW* Sites and at High-Scoring New *HSTW* Sites

	All New *HSTW* Sites		High-Scoring New *HSTW* Sites	
Mathematics Course	Average Mathematics Score	Percent of Assessed Students Taking the Course	Average Mathematics Score	Percent of Assessed Students Taking the Course
General, Business, or Consumer Mathematics	275.6 (0.4)	69	283.6 (0.7)	62
Pre-Algebra	280.1 (0.4)	61	288.2 (0.7)	59
Basic Algebra	282.1 (0.4)	54	289.5 (0.8)	54
Algebra I	292.2 (0.5)	52	301.5 (0.7)	58
Geometry	293.9 (0.5)	51	304.5 (0.7)	56
Algebra II	297.4 (0.5)	39	307.2 (0.8)	47
SREB Mathematics Goal	**295.0**			

Note: Differences in scores are statistically significant at the .05 level. Standard errors are indicated in parentheses. Percentages are rounded to the nearest whole number.

Despite teachers' dissatisfaction with students' mathematics skills, only 23 percent of them said that motivating students to learn more complex content was one of their most important objectives for career-bound students. Only 41 percent of teachers believed they did a good job of establishing higher expectations and prompting students to make the effort to achieve them. Yet teachers want to do better. In the Teacher Survey, teachers expressed the need for staff development on setting higher expectations and getting students to work harder.

Higher-Level Mathematics Courses Taught to High Standards Improve Mathematics Achievement

Mathematics achievement improves when career-bound students take mathematics courses that challenge them to use concepts from algebra, geometry, and elementary statistics to solve multi-step problems. Students enrolled in high schools that allow career-bound students to take General, Business, or Consumer Mathematics; Pre-Algebra; or Basic Algebra have much lower average mathematics scores. Courses limiting instruction to pencil and paper drills fail to help students understand connections among mathematics topics such as geometry, algebra, and measurement. Neither do they require students to apply mathematics topics to new situations and to use mathematics reasoning to solve problems related to life and work.

Transcripts of career-bound students participating in the 1993 *HSTW* Student Assessment revealed that students who took higher-level mathematics courses received significantly higher average mathematics scores than students who took mostly lower-level

Career-Bound Students Need Opportunities to Use Mathematics Knowledge and Skills

Teachers need to create opportunities for students to use mathematics knowledge in a variety of real-life situations and to report the results. Career-bound seniors at new *High Schools That Work* sites in 1994 said their mathematics teachers never encouraged them to learn mathematics by relating it to familiar situations and challenging problems. Other findings include:

- 33 percent of students said they never related mathematics content to its applications outside of mathematics class;
- 81 percent said they never had to complete a joint project involving mathematics and another area of learning for which they would receive a grade in both mathematics and the other area;
- 49 percent said they never had to complete a project using mathematics as it is used in the workplace;
- 74 percent said they never had to make an in-class presentation on a special mathematics project.

courses (see Table 8). The 39 percent of students who completed SREB's recommended mathematics curriculum[10] had significantly higher average mathematics scores (294.1 compared to 273.4 for students who did not complete the recommended curriculum). Students completing the recommended curriculum finished high school with an average of three Carnegie units in higher-level[11] mathematics courses. Students who did not complete the recommended curriculum graduated from high school with an average of only 1.3 Carnegie units in higher-level courses.

At all new *HSTW* sites, career-bound students who took mathematics courses such as Algebra I, geometry, and Algebra II had higher average mathematics achievement scores than students who took a sequence of lower-level courses (see Table 7).

The sequence in which students take mathematics courses is important in raising achievement. Thirty-nine percent of students who completed three mathematics courses (beginning with Algebra I and ending with Algebra II) exceeded the *HSTW* mathematics goal of 295.0 with an average score of 297.4 (see Table 7). Students who took lower-level mathematics courses had significantly lower achievement. More career-bound students at higher-achieving schools take more demanding mathematics courses and perform at higher achievement levels.

Table 8

Average Mathematics Scores by Level of Mathematics Courses Completed by Career-Bound Students at *HSTW* Sites in 1993

Level of Mathematics Completed	Average Mathematics Scores	Percent of Students	Mean number of credits earned in higher-level mathematics courses
Higher-Level (Completed SREB's recommended mathematics curriculum)	294.1 (.13)	39	3.0
Lower-Level (Did not complete SREB's recommended mathematics curriculum)	273.4 (.20)	61	1.3
SREB Mathematics Goal	**295.0**		

Source: Composite Report for New *High Schools That Work* Sites—Profile of the 1993 Vocational Graduates (SREB).

Note: The difference in scores is statistically significant at the .01 level. Standard errors are indicated in parentheses. Percentages are rounded to the nearest whole number.

[10] SREB recommends that career-bound students complete at least three credits in mathematics, including two credits with content equal to that of college preparatory mathematics. The student's program of study should include mathematics in the senior year.

[11] Higher-level is defined as Algebra I and higher.

Although taking more mathematics courses (including one in the senior year) is associated with improved mathematics achievement, the highest mathematics achievement is associated with completing a demanding sequence of courses. Students completing four or more credits in mathematics had an average score of 288.8, compared to an average score of 281.1 for those completing three credits and 273.6 for those completing two credits or less (see Table 9). The career-bound students who took a mathematics course in their senior year (45 percent) scored significantly higher in mathematics in 1994 than students who did not (285.1 compared to 279.6). However, taking four years of mathematics, including mathematics in the senior year, did not produce the highest scores on the *HSTW* Student Assessment; completing Algebra II resulted in the highest achievement. Career-bound students completing Algebra II in 1994 had an average mathematics score of 297.4, which is significantly higher than the average score of students taking four years of mathematics or taking mathematics during their senior year.

Schools dedicated to improving career-bound students' mathematics achievement should encourage them to complete at least one year of mathematics beyond Algebra I and geometry—either Algebra II or an integrated mathematics course covering key concepts from Algebra II, trigonometry, and elementary statistics.

Table 9

Average Mathematics Scores According to the Number of Mathematics Courses Taken by Career-Bound Students at All New *HSTW* Sites and at High-Scoring New *HSTW* Sites

	All New *HSTW* Sites		High-Scoring New *HSTW* Sites	
Number of Courses	Average Mathematics Score	Percent of Students	Average Mathematics Score	Percent of Students
Two or fewer	273.6 (.7)	21	281.2 (1.2)	20
Three	281.1 (.5)	48	290.7 (.8)	45
Four or more	288.8 (.7)	31	300.9 (1.1)	35

Note: Differences in scores are statistically significant at the .05 level. Standard errors are indicated in parentheses. Percentages are rounded to the nearest whole number.

Instructional Strategies Make a Difference in Mathematics Achievement

Data from new *HSTW* sites demonstrate that career-bound students' mathematics achievement improves when they have opportunities in and out of class to use and discuss mathematics as it relates to real circumstances and events. Students learn by manipulating objects, making things with their hands, solving problems, and performing tasks normally

associated with the workplace and other real-life situations. Students who have these experiences in mathematics courses have higher mathematics achievement than students who do not. The 47 percent of students reporting that their teachers frequently asked them to use mathematics to solve problems found typically in a vocational class or in a work setting had significantly higher average mathematics scores than students who were not asked to use mathematics in practical ways (see Table 10).

Table 10

Average Mathematics Scores and Frequency of Using Mathematics to Solve Real-Life Problems at All New *HSTW* Sites and at High-Scoring New *HSTW* Sites

Frequency of Using Mathematics to Solve Actual Problems from a Vocational Class or a Work Setting	All New *HSTW* Sites		High-Scoring New *HSTW* Sites	
	Average Mathematics Score	Percent of Students	Average Mathematics Score	Percent of Students
Once or twice a year	277.8 (.7)	29	289.2 (1.3)	28
More than twice a year	287.5 (.5)	47	297.5 (0.9)	48
SREB Mathematics Goal	**295.0**			

Note: Differences in scores are statistically significant at the .05 level. Standard errors are indicated in parentheses. Percentages are rounded to the nearest whole number.

To help students connect what is taught in mathematics with what is taught in other classes, teachers must know what others are teaching. Only eight percent of teachers completing the *HSTW* Teacher Survey in 1994 agreed strongly that they were familiar with the content and specific goals of courses taught by other teachers. Sixty-three percent said they never met with other teachers to plan ways to teach higher-level academic content to career-bound students.

Using mathematics in vocational classes is frequently associated with higher mathematics achievement. The 57 percent of students who said vocational teachers often stressed mathematics in vocational classes had an average mathematics achievement score of 285.0, compared to 278.9 for students who said their vocational teachers never or seldom stressed mathematics. Forty-six percent of students said they used mathematics to complete vocational assignments daily or weekly, and their average mathematics scores were higher than those of students who used mathematics in vocational assignments less frequently (see Table 11). The more students used mathematics in vocational classes, the higher they scored. This was true for all new *HSTW* sites in 1994.

Table 11

Students' Average Mathematics Scores and Frequency of Using Mathematics to Complete Vocational Assignments

Students said they used mathematics to complete vocational assignments	All New *HSTW* Sites		High-Scoring New *HSTW* Sites	
	Average Mathematics Score	Percent of Students	Average Mathematics Score	Percent of Students
Never	271.4 (1.1)	12	284.6 (2.0)	10
Twice a year or less	275.2 (0.8)	18	287.0 (1.5)	17
Monthly	284.0 (0.7)	24	292.3 (1.1)	28
Daily or weekly	286.5 (0.5)	46	296.1 (0.9)	46
SREB Mathematics Goal	**295.0**			

Note: Differences in scores for students who said they used mathematics daily or weekly versus never or twice a year or less are statistically significant at the .05 level. Standard errors are indicated in parentheses. Percentages are rounded to the nearest whole number.

Mathematics reasoning is an essential skill for most vocational fields. Yet more than 40 percent of career-bound seniors in 1994 said they seldom used mathematics in their vocational classes. Many vocational teachers do not believe that school and district administrators expect them to require students to use mathematics. In 1994, only 20 percent of vocational teachers said their administrators expected them, to any extent, to require students to use concepts from algebra and geometry to solve problems related to vocational studies. **School and central office administrators need to emphasize the importance of getting career-bound students to use mathematics frequently in vocational classes.**

Computer technology also promotes mathematics learning. Students who used a computer frequently to complete mathematics assignments had a higher average mathematics score than students who seldom did so (see Table 12). To raise achievement, mathematics and vocational teachers need to get students to complete challenging assignments on the computer.

Students Who Work Part-time Score Higher in Mathematics

Thirteen percent of students who completed the Student Questionnaire[12] at high-scoring new *HSTW* sites said they worked up to 15 hours per week. These students had higher average achievement scores than students who worked more or did not work at all (see Table 13).

[12] A Student Questionnaire consisting of 122 items accompanied the 1994 *High Schools That Work* Student Assessment.

Use of Technology in the San Marcos, Texas, School District Helped to Raise Mathematics Achievement of At-Risk Students

The San Marcos School District in Texas, with 60 percent Hispanic-American students and 44 percent considered economically disadvantaged, participated for two years in a project that used fiber-optic technology and graphing calculators to teach higher-level mathematics to at-risk students.

The Partnership for Access to Higher Mathematics (PATH Mathematics) project targeted eighth- and ninth-graders who originally did not expect to take demanding mathematics courses. PATH Mathematics provided students with a comprehensive, hands-on pre-algebra course that prepared them for Algebra I, geometry, and Algebra II. PATH's goal was to expand students' knowledge of mathematical concepts and the thinking skills necessary to apply those concepts.

As a result of this intensive effort to encourage mathematics study, student grades and attendance improved. In addition, statistically significant correlations were noted between student attitudes toward the program, the use of calculator technology, and student achievement. A number of PATH students enrolled in a summer mathematics enrichment program.

Many Would Have Dropped Out

"I see these students in the halls every day, and I know that some of them would have dropped out of school if they had not been involved in this program," said John Schulz, head of the mathematics department at San Marcos High School. Texas requires three mathematics courses (through the level of Algebra II) for high school graduation.

The program was a partnership among Southwest Texas State University, the school district, San Marcos Telephone Company, and the community (families, social service agencies, and professional associations). To facilitate field testing of activities, university faculty worked in cooperation with San Marcos High School teachers to deliver some of the instruction. They used interactive television made possible by the telephone company.

Many of the PATH manipulatives and the daily use of graphing calculators have been incorporated into all pre-algebra classes at San Marcos High School. Schulz hopes the total program, including interactive television, can be added to the Algebra I and Algebra II curriculum in the future. "The big plus for students who participated in the PATH program was the opportunity to interact with a university mathematics professor on a daily basis," he said.

Tutoring by College Students

The original PATH Mathematics project also included role-model tutoring by minority college students who were seeking a major or minor concentration in mathematics. A support system, assisting students with health, social, economic, and motivation problems that can impair learning, was built into the program. Community business and civic organizations contributed mentors and classroom speakers.

"Because every community in the United States has access to a telephone company, PATH Mathematics can be replicated virtually anywhere," said Project Director Paul Kennedy, head of the mathematics department at Southwest State Texas University. "By joining forces, business and education can use fiber-optic technology to eliminate educational inequities and to improve academic excellence and equality."

Table 12

Students' Average Mathematics Scores and Frequency of Using a Computer to Complete Mathematics and Vocational Assignments

Students said they used a computer	All New *HSTW* Sites		High-Scoring New *HSTW* Sites	
	Average Mathematics Score	Percent of Students	Average Mathematics Score	Percent of Students
Once or twice a year to complete mathematics assignments	277.4 (0.9)	22	288.0 (1.5)	20
More than twice a year to complete mathematics assignments	288.3 (0.8)	21	301.1 (1.4)	22
SREB Mathematics Goal	**295.0**			

Note: Differences in scores are statistically significant at the .05 level. Standard errors are indicated in parentheses. Percentages are rounded to the nearest whole number.

Extra Help and Family Support Improve Mathematics Achievement

To improve mathematics achievement, school leaders and teachers need to encourage career-bound students to enroll in rigorous mathematics courses taught to high standards. Parents need to help their children with their studies, including requesting extra help for students as needed.

STAR Mathematics Program Features Built-In Extra Help

Extra help is a built-in feature of the STAR (Short Term Achievement and Reward) algebra program at Hoke County High School in Raeford, North Carolina. All students at Hoke must take Algebra I. General and Consumer Mathematics have been eliminated from the curriculum.

Students in STAR algebra cannot move forward in the course until they pass a test on the material just covered. For example, students who score less than 70 percent on a weekly test must attend a "second chance" class. The class meets for an hour after school on Tuesdays, Wednesdays, and Thursdays.

Students must have an average grade of at least 70 in a nine-week period or be required to repeat the material in a subsequent nine weeks. A summer program (referred to as the fourth quarter of STAR) is available for students who do not pass the required algebra content during the regular school year.

Donna Kennedy, a STAR mathematics teacher, points to the success of the program. "The number of failing students declined from 35 to only five after one year of the STAR program," she said. "As more students have enrolled in the program, the average scores have continued to improve." A history of success in algebra has given more students the confidence to take geometry, Kennedy noted.

Table 13
Students' Average Mathematics Scores and Number of Hours Per Week Spent on the Job

Amount of time spent on the job each week	Average Scores of Students at High-Scoring New *HSTW* Sites	Percent of Students Responding
None	291.2 (1.2)	27
15 hours or less	297.5 (1.7)	13
16 hours or more	291.3 (1.8)	60
SREB Mathematics Goal	**295.0**	

Note: Differences in scores are statistically significant at the .05 level. Standard errors are indicated in parentheses.. Percentages are rounded to the nearest whole number.

Teachers and counselors need to develop a system for identifying students who would benefit from extra help. In 1994, 75 percent of students said they received extra help in mathematics from their mathematics teachers, while few students reported receiving extra help from a tutor or resource teacher (see Table 14). Moreover, when schools develop a system of extra help, students' mathematics performance improves.

Table 14
Average Mathematics Scores and Sources of Extra Help in Mathematics

	All New *HSTW* Sites		High-Scoring New *HSTW* Sites	
Students said they received help from:	Average Mathematics Score	Percent of Students	Average Mathematics Score	Percent of Students
Mathematics Teacher	281.3 (0.4)	76	292.0 (0.7)	75
Resource or Special Teacher	267.8 (0.9)	14	277.9 (1.8)	11
Tutor	275.0 (1.0)	14	285.2 (1.6)	14
SREB Mathematics Goal	**295.0**			

Note: Differences in scores between all new *HSTW* sites and high-scoring new *HSTW* sites are statistically significant at the .01 level. Standard errors are indicated in parentheses. Percentages are rounded to the nearest whole number.

A Guidance System Can Reinforce the Importance of Mathematics

Career-bound students' mathematics achievement improves when those who advise them about school studies (administrators, counselors, academic and vocational teachers, and parents) speak with one voice about the relationship of mathematics to success in the future. More students at high-scoring new *HSTW* sites reported that their teachers and counselors encouraged them to take more challenging mathematics courses (54 percent compared to 51 percent at low-scoring sites). These students also scored significantly higher in mathematics (297.9) than those who were not encouraged to take challenging mathematics courses (285.9).

Unfortunately, many educators and parents question whether career-bound students need to take a challenging mathematics curriculum and whether they are capable of completing it. Some high schools allow students to choose mathematics courses that they can pass without exerting much effort. A career-bound senior at one school expressed the feelings of many other students: "Why should I take Algebra II if I don't have to?"

The experiences of 12,000 career-bound seniors (derived from the 1994 Student Questionnaire) reflect the need for more guidance in helping students pursue a challenging mathematics curriculum:

- 80 percent said they never met with their parents and a counselor or a teacher advisor to plan a four-year program of study;
- 27 percent said no one helped them develop a four-year program of study;
- 32 percent said they needed more encouragement to take a combination of challenging academic and vocational courses;
- 35 percent said a counselor or a teacher advisor never reviewed their four-year plans with them;
- 50 percent said they received no help before the 10th grade in planning a high school program of study;
- 34 percent said they needed more information and counseling regarding future educational opportunities;
- 25 percent said they were not satisfied with the help they received in selecting courses.

Forty-one percent of career-bound students responding to the 1994 Student Questionnaire said they planned to enroll in further study after high school. This group's average achievement score in mathematics was 283.7, which is substantially below the *HSTW* mathematics goal of 295.0 and the average score of academic students nationally (316.8). Students need assistance by the beginning of the ninth grade in selecting mathematics courses for the next four years. If they do not receive such help, they are unlikely to take the two or three mathematics courses needed for success in further education and a career.

The Impact of Socioeconomic Status and Racial/Ethnic Identity on Mathematics Achievement

SREB compared the achievement of students who belong to four categories of socioeconomic status and racial/ethnic identity at high-scoring and low-scoring[13] new *HSTW* sites. The comparison revealed major differences in career-bound students' mathematics achievement (see Table 15).

Table 15

Comparison of Average Mathematics Achievement Scores of Career-Bound Students by Socioeconomic Status and Racial/Ethnic Identity at High-Scoring New *HSTW* Sites and Low-Scoring New *HSTW* Sites

	Low Parental Education/White		High Parental Education/White		Low Parental Education/High Minority Representation		High Parental Education/High Minority Representation	
	High-Scoring Sites	Low-Scoring Sites	High-Scoring Sites	Low-Scoring Sites	High-Scoring Sites	Low-Scoring Sites	High-Scoring Sites	Low-Scoring Sites
Average Mathematics Score	289.8 (1.2)	269.1 (1.0)	296.4 (1.1)	274.1 (3.7)	289.9 (2.5)	266.4 (1.1)	291.2 (1.4)	271.4 (0.9)

Note: Low parental education means that some parents did not complete high school, some completed high school, and a few received minimum training after high school. High parental education means that all parents completed high school and one or more years of study at a postsecondary institution.

White means that the school enrollment included 80 percent or more white students. High minority representation means that the school enrollment included 32 or more percent minority students.

Differences in scores at high-scoring and at low-scoring sites are statistically significant at the .01 level. Standard errors are indicated in parentheses.

New *High Schools That Work* Sites Face Six Major Challenges in Raising the Mathematics Achievement of Career-Bound Students

Schools face six major challenges in improving the mathematics knowledge and skills of career-bound students. These challenges include:

1. Raising Expectations for Mathematics Learning

The school and the community must agree on the need for higher expectations for all students. School and system administrators, mathematics and vocational teachers, parents, and students need to recognize the importance of mathematics in a business world in which symbols and abstract concepts are replacing physical responses.

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[13] Low-scoring sites are high schools whose students scored in the lower 33 percent of all schools administering the *High Schools That Work* Student Assessment in mathematics in 1994.

High-Scoring *High Schools That Work* Sites Use Different Instructional and Guidance Strategies

School leaders and teachers who want to improve student learning need to pay attention to school and classroom practices at higher-achieving schools. Vast differences exist in mathematics instruction at high-scoring and at low-scoring *High Schools That Work* sites. Reports by students recounting school experiences at these sites revealed that:

- More career-bound students complete more courses from the college preparatory curriculum. (Algebra I, Algebra II, geometry, trigonometry, and calculus) at high-scoring schools. Low-scoring schools are likely to have rigid tracking systems discouraging career-bound students from completing higher-level mathematics. At high-scoring schools:
  - Fewer career-bound students take general mathematics, pre-algebra, and basic algebra;
  - More students take mathematics in the senior year;
  - More students complete four years of mathematics.
- High-scoring schools hold career-bound students to higher standards and help them work harder to meet those standards. At high-scoring schools, career-bound students:
  - Perform at a higher level than students who take the same mathematics courses at low-scoring schools;
  - Receive more help in mathematics from their vocational teachers;
  - Describe most courses as challenging and exciting;
  - Are encouraged to take more mathematics courses;
  - Receive extra help in mathematics from a mathematics teacher, a resource teacher, or a tutor;
  - Report doing more homework.
- High-scoring schools raise expectations in vocational courses by requiring students to use mathematics to complete assignments. More students at high-scoring schools report that:
  - Their vocational teachers often stress mathematics;
  - They use mathematics frequently to solve problems in vocational classes and at work;
  - Their jobs are related to their vocational studies;
  - Their vocational teachers assign more homework.
- Mathematics teachers at high-scoring schools use student-centered instruction to help students connect mathematics to its use in the real world. More students at high-scoring schools:
  - Use mathematics as it is used in the workplace to complete challenging projects more than twice a year;
  - Use computers in completing mathematics assignments;
  - Do assigned homework.

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High-Scoring *High Schools That Work* Sites *(cont'd from page 21)*

- High-scoring schools provide an educational and career guidance system that helps career-bound students select and pursue a challenging, focused program of study. More students at high-scoring sites:
  - Are encouraged to take a combination of high-level academic courses and modern vocational courses;
  - Receive assistance in planning a program of study before grade 9;
  - Are satisfied with the help they receive in course selection;
  - Plan to pursue further study after high school and receive help in planning for it;
  - Receive help from a counselor or a teacher advisor in developing and annually reviewing a four-year program of study;
  - Discuss their programs of study with their parents.

School leaders, in cooperation with teachers and the community, can take specific actions to raise expectations. They include:

Action One: Engage community and business representatives in helping teachers, students, and parents understand the need for workers who can use mathematics knowledge and skills. (Parents play a crucial role in motivating their children to make the effort to learn challenging mathematics content.)

Action Two: Set a goal, and revise curriculum and instructional practices until all students meet it. SREB recommends that each *HSTW* site set a goal to significantly raise the percentage of career-bound students who reach the *HSTW* mathematics goal of 295.0 in 1996 and 1998. This would mean that considerably more students would be able to:

- Interpret and eventually perform complex operations using fractions and decimals;
- Understand measurement, and apply their knowledge of geometry in solving measurement problems;
- Analyze and interpret data for determining the probability of a simple event;
- Understand functions, and solve for missing variables in a range of problems involving algebra;
- Use reasoning and analytical skills to recognize and solve problems from the real world.

Action Three: Prompt more students to complete a sequence of mathematics courses containing high-level mathematical concepts. This effort involves removing courses such as General Mathematics, Business Mathematics, Consumer Mathematics, Basic Algebra, and Pre-Algebra from the high school curriculum (except for students with Individual Educational Plans). In some districts, the school board has established a policy requiring students to complete a challenging mathematics curriculum as a condition for receiving a high school diploma.

Action Four: Guarantee that the school board will pay for any non-credit developmental or remedial mathematics courses needed by students who complete the recommended mathematics sequence and enter a postsecondary institution immediately after graduation.

Action Five: Have the mathematics department to develop an end-of-course examination for each course. Department-wide end-of-course examinations help teachers hold students to higher standards and encourage students to work harder.

2. Getting students to see the need for mathematics outside of class and school

Vocational teachers are in an ideal position to promote students' mathematics learning, yet many of them fail to do so. School leaders need to help vocational teachers develop a curriculum and instructional plan for improving mathematics learning in vocational classes. Such a plan should involve, at minimum:

SREB's Recommended Sequence of Mathematics Courses for Career-Bound Students

The following sequence (when it engages students in using mathematics operations to solve real-world problems and supports students' efforts to learn) will help more career-bound students meet the *High Schools That Work* mathematics goal:

- Pre-algebra in grades 7 and 8;
- Algebra I and geometry, or a "mathematics for work" course that uses contextual learning strategies to teach the essential concepts of Algebra I and geometry;
- Algebra II/trigonometry, or an advanced integrated "mathematics for work" course that covers the essential content of Algebra II, trigonometry, and elementary statistics.

SREB believes that an applied or contextual mathematics course such as "mathematics for work" should be equivalent to college preparatory mathematics. Equivalency means that the applied course:

- Contains the essential content of Algebra I, geometry, Algebra II, trigonometry, and elementary statistics;
- Is taught in a conceptual way that allows students to use abstract mathematics procedures in real-life activities;
- Holds students to the high standards of college preparatory algebra and geometry;
- Is fast-paced. Students who fall behind are required to do extra work (including one hour or more of homework daily) outside of class to meet the high standards.

Schools offering applied mathematics courses need to make sure that students are held to high standards, that they complete assignments outside of class, and that they cover the breadth of material found in college preparatory courses.

Duluth (GA) High School Teachers Invite Business Representatives to Demonstrate Uses of Mathematics in the Workplace

Mathematics teachers at Duluth High School in Duluth, Georgia, invited 23 business representatives to give students a taste of on-the-job problems and situations involving mathematics. A mortgage broker, a real estate agent, engineers, a fast-food restaurant manager, bankers, a doctor, and a financial planner were among those participating in a workshop at the school. Real-life examples included:

- A transportation engineer used calculus to figure the dimensions of drainage holes, underground pipes, and curbing for a road-building project;
- An investment banker used algebra to calculate how much a person needs to invest to ensure financial security;
- A hospital radiation physicist used calculus to determine radiation dosages for patients;
- A wallpaper hanger figured the number of rolls of wallpaper needed to cover a room.

Mathematics teacher Donna Deegan explained how the project began: "We got tired of hearing students complain, 'When are we ever going to have to use this?'"

- Identifying major mathematical concepts and procedures needed by students to advance on the job and in further study. In writing a plan, vocational teachers can use the mathematics content and process areas covered in the *HSTW* Student Assessment.

- Assigning projects for students to complete at school, at home, and on the job; These projects should require students to use high-level mathematical concepts and to make written and oral reports on their use of mathematics.

- Arranging for worksite mentors to help students understand the role of mathematics knowledge and skills in the workplace;

- Helping students acquire mathematics knowledge for completing major laboratory or shop projects; Students can ask mathematics teachers to review needed concepts in class.

- Determining how to measure whether students know and can correctly apply mathematical concepts and procedures; Vocational teachers can enlist workplace experts to help students understand the use of mathematics in career fields.

School leaders and teachers need to emphasize the importance of using mathematics in all classes, not just in mathematics and vocational classes. Mathematics teachers can take the lead in helping all teachers focus on a major mathematics area in each grading period. For example, the emphasis could be on measurement in the first grading period; geometry in the second period; data collection, analysis, and interpretation in the third period; and mathematical reasoning and analytical skills in the fourth period.

3. Helping mathematics teachers use a variety of teaching strategies

Teachers who rely heavily on lectures and drill sheets are less likely to produce students who can solve multi-step problems or apply mathematical concepts in a variety of situations.

Howard Gardner's seven intelligences theory[14] can serve as a framework for teachers in helping all students learn mathematics. The use of Gardner's theory in this publication is not meant to imply that teachers should label students by type of intelligence. The purpose in using the theory is to encourage teachers to vary their instructional strategies in teaching mathematics to all students.

Vocational Technical Center Makes it Clear: Mathematics Counts in Every Career Area

Randolph County Vocational-Technical Center in Elkins, West Virginia, is one of the *High Schools That Work* program's most-improved schools (based on the 1990 and 1993 *HSTW* Student Assessments in reading, mathematics, and science). Seventy-five percent of the center's students completing the *HSTW* Student Questionnaire in 1993 said their vocational teachers often emphasized mathematics skills. These students' mathematics achievement scores significantly exceeded the SREB goal of 295.

When prospective students visit the center, vocational teachers make one thing very clear: Mathematics is important for success in every career field. During the visits, teachers illustrate the use of mathematics in real life and encourage students to take high-level mathematics courses in preparation for success in school and at work.

The program of study in each career area at the center includes at least three years of mathematics at the college preparatory level. Algebra I and Applied Mathematics I are the lowest-level mathematics courses offered.

Vocational teachers frequently invite mathematics teachers to join them in explaining the mathematics-related aspects of a vocational unit such as measuring and cutting rafters in a construction class. A trigonometry teacher is conducting joint projects with several vocational teachers this year, including having students spend class time for one week observing the use of mathematics in vocational areas such as drafting, electricity, millwork and cabinet making, industrial maintenance, and health occupations.

Vocational teachers in areas such as industrial maintenance and electricity provide technical mathematics resource books to help students understand mathematical concepts related to their vocational studies.

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[14] Howard Gardner, *Frames of Mind: The Theory of Multiple Intelligences*. (New York: Basic Books, 1983) Thomas Armstrong, *Multiple Intelligences in the Classroom*, (Alexandria, Virginia: Association for Supervision and Curriculum Development, 1994).

New Texas *High Schools That Work* Sites Use Effective Practices to Advance Mathematics Learning

Three Texas high schools that participated in the *High Schools That Work* Student Assessment for the first time in 1994 are using effective school and instructional strategies. Vocational completers at these schools, including a high percentage of students from minority and low-income backgrounds, outscored students at many other *HSTW* sites in mathematics. One of the schools exceeded the SREB mathematics goal.

North Side High School

Students who took the *HSTW* mathematics assessment at North Side High School in Fort Worth in 1994 had higher average scores than average scores for students from all other new *HSTW* sites. All academic and vocational teachers at the school are involved in strengthening students' mathematics knowledge and skills. Vocational teachers attended workshops to become more familiar with ways to incorporate high-level mathematical concepts into vocational courses. The school's athletic department is also involved. For example, one coach asked students to measure the distance around the school track.

North Side students who successfully complete Algebra I can enroll in a state-developed course known as Mathematics of Money. The course develops students' mathematics skills through activities such as group work and special projects. In one hands-on activity, students simulated purchasing an automobile. They shopped for the best price, compared interest rates, and figured an acceptable monthly payment. "This course is taught at a high level," said Andrew Laing, chairman of the school's mathematics department. "It is not a dumping ground for less successful students."

Tomball High School

The average score of students who took the *HSTW* Student Assessment mathematics test at Tomball High School in Tomball, Texas in 1994 exceeded the *HSTW* goal. The school district requires 24 credits for high school graduation, including credits in Algebra I and II and geometry. Low-level mathematics courses have been eliminated from the schedule.

Tomball students participate in special Mathematics Days and Mathematics Weeks during which every teacher emphasizes mathematics. Many of the teachers use integrated lessons prepared by a group of mathematics instructors at the school.

"Two things are making a difference in achievement at our school," said Robert Todd, principal at Tomball. "We believe in high expectations for everyone, including teachers as well as students. And we have a caring faculty and staff who work hard to help students succeed."

Los Fresnos High School

In 1994, the average mathematics score for vocational completers at Los Fresnos High School in Texas was very close to the SREB mathematics goal of 295. Los Fresnos is engaged in a campaign to raise the mathematics achievement of all students.

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New Texas *High Schools That Work* Sites *(cont'd from page 26)*

Four years ago the school raised expectations for students by increasing the graduation requirements from 21 to 24 credits (including credits in Algebra I, geometry, and Algebra II) and by eliminating low-level courses such as pre-algebra.

The school's assistant principal, who has a strong mathematics background, visits mathematics classrooms regularly and helps teachers plan challenging lessons. Ninety-minute class periods enable teachers to use a variety of instructional methods, including hands-on activities.

For the past two years, mathematics teachers met and planned lessons together three days each week. The school's mathematics improvement plan includes collaboration between mathematics and vocational teachers to create challenging, integrated projects in vocational areas such as environmental science and marketing.

The seven intelligences, the key questions for teachers to ask themselves, and some suggested answers include:

- **Linguistic Intelligence**—*How can I use written and oral communication to help students understand mathematical concepts?* Ask students to scan technical manuals from their vocational courses to find examples of mathematical procedures to bring to class. Ask students to write and solve mathematics problems from their vocational studies, a work setting, or the community. Require students to keep a journal of major mathematical concepts and the rules and principles for applying each concept. Ask students to make oral presentations on the procedures used in solving problems.

- **Logical-Mathematical Intelligence**—*How can I relate calculations, logic, and critical thinking skills to other courses, to current events, and to everyday situations?* Give students opportunities to talk about mathematical concepts in and out of class. Ask students to identify uses of mathematics in vocational courses and in the workplace. Require students to solve problems related to their career studies and to real life by using concepts studied in mathematics classes.

- **Spacial Intelligence**—*How can I use visual aids, visualizations, color, art, or metaphors in teaching mathematics?* Sketch the geometric concepts involved in designing a house, assembling a robot, or building a bridge. Help students use graphics and symbols to depict mathematical concepts.

- **Bodily-Kinesthetic Intelligence**—*How can I use hands-on activities to help students understand mathematics?* Encourage students to use computers and graphic calculators to complete mathematics assignments. Work with vocational teachers to develop long- and short-term projects requiring students to use mathematical concepts. Have students design and make manipulatives that demonstrate different mathematical concepts, geometric figures, etc. Ask students to keep charts on their physical development—strength, growth, endurance, caloric intake and derivation from fats, carbohydrates, sugars, and protein; to

analyze high school athletic events, compile data concerning offensive and defensive actions, and analyze and interpret data. Create and plan mathematics labs; work with science teachers to incorporate mathematics into science labs.

- **Musical Intelligence**—*How can I use music or musical sounds in teaching mathematics?* Have students put mathematical concepts into lyrics and lead the class in chanting those lyrics. Ask students to plot the rhythm of selected music; prepare a bar graph showing the duration of different notes; link mathematical concepts of volume, frequency, measurement, patterns, and horizontal and vertical lines to musical concepts; conduct a survey, collect and analyze data, and prepare written reports regarding others' views on music; and determine the different possibilities of note combinations from the bars of a waltz or march.

- **Interpersonal Intelligence**—*How can I engage students in working in groups to do projects and homework related to mathematics learning?* Create study groups that allow students to work together to find possible mathematics applications. Use board and simulation games to help students understand and use mathematics. Let students share in small groups the steps they followed to solve a particular mathematics problem. Assign homework for students to do in teams outside of class and assess their understanding of the content.

- **Intrapersonal Intelligence**—*How can I evoke students' memories and personal feelings in teaching mathematics?* Ask students to create problems based on their experiences in using mathematical concepts, and ask them to reflect on the use of those concepts at home, in a work setting, or in another classroom. Ask students to write a journal entry on the relationship of mathematics to their lives. Let students select their own mathematics projects. Ask students to set daily goals for improving mathematics learning. Let them use graphs, charts, journals, and other methods to record their progress.

Block Scheduling in Lexington (OK) School System Helps Students Achieve at a Higher Level

In the fall of 1994, the Lexington School System in Oklahoma converted to block scheduling. The schedule consists of three 90-minute blocks per day for courses such as mathematics, science, language arts, and social studies, plus two 45-minute "encore periods" for other courses or activities. Students who need extra help in mathematics or other subjects use the encore periods to seek individual assistance from their own teachers or from other teachers. Teachers and students use the encore periods to work on projects with their peers.

The 90-minute classroom blocks allow mathematics teachers to cover more material each day, to team teach, and to integrate mathematics with vocational studies such as agriculture or business. Teachers are expected to vary their instructional approaches during the block and to take the learning styles of students into consideration in planning classroom activities.

Superintendent Rick Moss says block scheduling is proving to be very effective in getting students to achieve at a higher level.

State Actions in North Carolina Contribute to Increased Mathematics Achievement

North Carolina has taken major steps in the past decade to upgrade mathematics instruction and achievement. End-of-course testing was implemented for Algebra I in 1986, for geometry in 1989, and for Algebra II in 1990. A K-8 mathematics curriculum adopted in 1989 emphasizes skills such as problem solving, mathematics applications, and data analysis.

The North Carolina Board of Education eliminated low-level courses such as General Mathematics and Consumer Mathematics statewide. In 1991 the state board voted to require all students to complete Algebra I, beginning with the graduating class of 1996. Most school systems in the state moved quickly in that direction.

End-of-course tests in Algebra I, geometry, and Algebra II may be an incentive for students to upgrade their mathematics learning and for teachers to make coursework more challenging. At 12 new *High Schools That Work* sites in North Carolina, career-bound students scored higher on the *HSTW* Student Assessment examination in mathematics than similar students at all 197 new *HSTW* sites in 1994. Students at the 12 new sites scored an average of 291.4 in mathematics, a score that is very close to the SREB mathematics goal of 295. Thirty percent of these students are racial or ethnic minorities.

An examination of the course-taking patterns of career-bound students at the 12 new North Carolina sites revealed that more students at these sites than at the other new ones took higher-level mathematics. For example:

- 70 percent of students at the 12 new sites (compared to 51 percent at other new sites) completed geometry;
- 55 percent (compared to 39 percent) took Algebra II;
- 57 percent (compared to 45 percent) took a mathematics course in the senior year;
- 46 percent (compared to 31 percent) completed four years of mathematics.

Evidence shows that mathematics courses at the 12 new sites were taught to higher standards than similar courses at other new *HSTW* sites. More students (64 percent) at the 12 new sites said they were encouraged to take more mathematics courses. Seventy-six percent of students at the 12 sites (compared to 64 percent at all other new sites) reported doing homework for an hour or more each day.

Students at the 12 new sites were more actively engaged in completing assignments and projects than were students at other new *HSTW* sites. More students at the 12 sites said they made classroom presentations on mathematics projects, and more of them reported using computers to complete mathematics assignments.

4. Developing a guidance system that involves parents in helping career-bound students plan and complete a challenging program of mathematics studies

Beginning in middle or junior high school, students need to plan to take challenging mathematics courses in high school. Toward the end of the eighth grade, students should meet with their parents and a counselor or a teacher advisor. In the meeting, the family and the counselor or advisor should review the student's mathematics achievement, discuss his/her educational and career plans, and devise a challenging four-year program of academic and vocational study. The program should include extra study as needed during an extended school day, week, or year.

The same counselor or teacher advisor needs to meet annually with the student and his/her parents to review the program of study and to determine the student's progress, especially in mathematics. Mathematics teachers in middle school and high school need to

High School 'Measures Up' in Week-Long Emphasis on Mathematics

At Will Rogers High School in Tulsa, Oklahoma, one week in the fall of 1994 was devoted to a school-wide interdisciplinary project focusing on measurement. The event, known as Rogers Rules, resulted from observations by teachers that too few students seemed to know how to measure distances, capacity, etc.

During the week of cross-curricular activities, mathematics students made estimates and did conversions; business students formatted letters and documents; graphic arts students performed layout and design activities; marketing students designed displays; and students in other disciplines completed a variety of activities calling for measurement skills. Competitive events were held each day to heighten awareness of the event and to recognize students' projects.

Student activities during the week included calculating:

- The seating capacity of the gymnasium;
- The average height of the faculty;
- The distance between two rooms of the school;
- The number of bricks in the school building walls;
- The number of square feet of glass in the school windows.

The week concluded with an assembly program during which a local printing industry representative discussed the uses of measurement in the workplace. Students described their projects, answered questions about their methods, and received prizes.

The project called for students to demonstrate their knowledge of measurement through Rogers Rules activities and performance on written pre- and post-tests.

An interdisciplinary team of teachers planned the measurement project. They hope to schedule several school-wide thematic events each year, focusing on other interdisciplinary topics.

Enrichment Program Helps Minority Students Succeed in High-Level Mathematics Courses

The University of Houston is preparing a group of teachers from nearby inner city high schools to conduct a student enrichment program that has been successful in raising the mathematics achievement of minority college freshman in Texas and California. The centerpiece of the program is a for-credit mathematics workshop that students take concurrently with a challenging mathematics course.

In the workshop, students work in groups to complete a series of illustrated word problems, many of them relating to real life and work. The workshops also use computer technology and include activities such as discussion, games, contests, problem solving, and mock examinations.

"This is not a remedial course," said Sylvia Foster, director of the Scholar Enrichment Program (SEP) at the University of Houston. "This course is for students whose personal situations have traditionally prevented them from taking and learning high-level mathematics." The workshop approach has helped minority students abandon an "I can't do it" attitude and decide to remain in school longer.

The results are impressive. In the program's second year, all workshop students earned a C or higher in the mathematics courses they were taking. Ninety percent of these students were enrolled in Calculus I. In the spring and fall of 1994, several students were removed from scholastic probation, and several went from suspension status to the dean's list.

The Scholar Enrichment Program will be introduced at the high school level in Houston during the fall of 1995. In this setting, it will be incorporated into a 90-minute mathematics block. The instructor will introduce the lesson in the first 30 minutes, and students will participate in enrichment activities during the last hour.

develop a series of learning experiences that will allow students to relate mathematical concepts to a variety of career fields. These experiences might include interviewing carpenters, engineers, accountants, scientists, electronic technicians, machinists, statisticians, and others regarding the relationship of mathematics to advancement in the workplace.

5. Holding students to higher standards in mathematics courses and providing extra help for those who need it

Encourage students who fail mathematics in any grading period throughout grades 9 and 10 to seek extra help. Staff the school's extra help system with academic and vocational teachers who are committed to helping students meet higher standards. Help parents understand the system and ask them to sign an agreement supporting their children's participation.

In developing an extra help system, schools need to increase the amount of time available for student learning. Extra help is particularly important for students who have difficulty understanding higher-level mathematics content and applying it to complex problems. School leaders can provide more instructional time by revising the school schedule from a traditional six- or seven-period day to a block schedule that gives students more time in mathematics class.

Tomball (TX) High School Establishes Applied Mathematics Laboratory

To provide students with hands-on applications of mathematics concepts, mathematics teachers at Tomball High School in Tomball, Texas, take their students to a central applied mathematics laboratory. The laboratory contains all 36 instructional units of the Applied Mathematics I and II courses developed by the Center for Occupational Research and Development (CORD).

Applied Mathematics contains the mathematics content considered essential for the workplace, including algebra, geometry, trigonometry, statistics, and the use of computers to solve problems. Students engage in a variety of activities relating mathematics to real life.

When teachers at Tomball want to illustrate mathematics concepts, they schedule time for their students in the laboratory. One mathematics teacher coordinates the lab, and student aides assemble the needed equipment before the class arrives.

Tomball teachers participate in CORD training and school-sponsored staff development workshops to learn when and how to use the Applied Mathematics materials in their courses.

A school's extra help system can include before- and after-school programs in which students receive assistance with homework and other assignments. Evening, weekend, and summer programs also give students opportunities to learn higher-level content.

6. Supporting mathematics and vocational teachers with staff development, resource materials, and time to meet with other teachers to devise ways to improve students' mathematics learning

Many mathematics teachers need help in using a variety of proven instructional approaches to advance mathematics learning. Teachers should have opportunities to review information on new teaching methods, to watch demonstrations, to try the methods, and to receive coaching from colleagues or experts while implementing and refining the strategies in their classrooms.

Vocational teachers need staff development in planning laboratory projects that require students to use several mathematical concepts and procedures.

School administrators can support mathematics and vocational teachers by:

- Encouraging them to explore the community to learn how mathematics is used in the workplace by engineers, physicians, technicians, accountants, bankers, and others.
- Providing an organizational structure that gives mathematics and vocational teachers time to work together to plan integrated mathematics activities such as thematic units, joint learning projects, and team teaching; applied learning strategies in mathematics classes; additional mathematics content in vocational courses; and students' active engagement in higher-level mathematics.

- Developing new ways to assess students' performance in learning mathematical concepts. Mathematics teachers who use a variety of instructional strategies will need to develop new ways to measure students' performance. The National Council of Teachers of Mathematics (NCTM) cites three basic sources of information:
  - Observation of student work;
  - Student responses to questions;
  - Examinations of student products.[15]

NCTM recommends balance in the use of multiple sources and methods of assessment to measure student progress and improve student learning.

Conclusion

To compete for good jobs and to continue their education, career-bound high school students need to develop the capacity to use mathematics. SREB's experience with the *High Schools That Work* program demonstrates that these students can achieve at a higher level. School leaders, teachers, and parents at new *HSTW* sites must believe that career-bound students need and can learn mathematics skills to solve work-related problems.

The key to raising mathematics achievement at new *HSTW* sites is to develop a sequence of courses that will:

- Teach career-bound students the essential content of college preparatory mathematics courses;
- Help these students apply mathematical concepts and procedures to a variety of real-life situations;
- Provide extra help and time for these students to learn challenging mathematics content.

New *HSTW* sites must stop teaching the same old mathematics in the same old way. Otherwise, student achievement will not keep pace with the technological advances of business and industry and the requirements of postsecondary education. The National Council of Teachers of Mathematics (NCTM) standards can be a framework for new *HSTW* sites in revamping instruction and emphasizing mathematics skills in science and other courses.

Leaders and teachers who want to improve students' mathematics scores need to study the baseline mathematics assessment results, develop a plan for improving curriculum and instruction, implement the plan, and evaluate the changes. They need to focus on continuous improvement of school practices and attitudes.

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[15] National Council of Teachers of Mathematics. (1993) *Assessment Standards for School Mathematics (Working Draft)*. Reston, VA: National Council of Teachers of Mathematics.

SREB-State Vocational Education Consortium
High Schools That Work Program

Goals

- To increase the mathematics, science, communication, problem-solving, and technical achievement and the application of learning for career-bound students to the national average of all students.
- To blend the essential content of traditional college preparatory studies—mathematics, science, and language arts—with quality vocational and technical studies by creating conditions that support school leaders, teachers, and counselors in carrying out the key practices.

Key Practices

- Setting higher expectations and getting career-bound students to meet them.
- Increasing access to challenging vocational and technical studies, with a major emphasis on using high-level mathematics, science, language arts, and problem-solving skills in the context of modern workplace practices and in preparation for continued learning.
- Increasing access to academic studies that teach the essential concepts from the college preparatory curriculum through functional and applied strategies that enable students to see the relationship between course content and future roles they envision for themselves.
- Having students complete a challenging program of study with an upgraded academic core and a major. An upgraded academic core includes at least four years of college preparatory English and three years each of mathematics and science, with at least two years in each area equivalent in content to courses offered in the college preparatory program. The major includes at least four Carnegie units in a career or academic major and two Carnegie units in related technical core courses.
- Providing students access to a structured system of work-based and high-status school-based learning—high school and postsecondary—collaboratively planned by educators, employers, and workers and resulting in an industry-recognized credential and employment in a career pathway.
- Having an organizational structure and schedule enabling academic and vocational teachers to have the time to plan and provide integrated instruction aimed at teaching high-status academic and technical content.
- Having each student actively engaged in the learning process.
- Involving each student and his/her parent(s) in a career guidance and individualized advising system aimed at ensuring the completion of an accelerated program of study with a career or academic major.
- Providing a structured system of extra help to enable career-bound students to successfully complete an accelerated program of study that includes high-level academic content and a major.
- Using student assessment and program evaluation data to continuously improve curriculum, instruction, school climate, organization, and management to advance student learning.

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High Schools That Work

The *High Schools That Work* program is the nation's largest and fastest growing effort to raise the achievement of career-bound high school students. Created by the Southern Regional Education Board-State Vocational Education Consortium, the program includes over 350 school and school system sites in 19 states.

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